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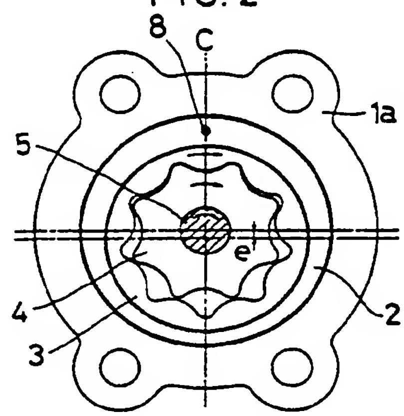
(54) **Variable discharge gear pump.**

(57) An improved variable discharge internal gear pump having a pump housing and a gear set mounted in the pump housing and consisting of an outer rotor and an inner rotor. The relative position between the gear set and the suction port and the discharge port formed in the pump housing are variable, thereby making the discharge volume variable. Three means for this purpose are proposed.

FIG. 2



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VARIABLE DISCHARGE GEAR PUMP

The present invention relates to a variable discharge gear pump equipped with internal gears. It is suited for use as a pump which is required to have a variable suction/discharge capacity to save power, such as for use with an automatic transmission.

A vane pump which is a typical variable discharge pump has problems that the number of parts is so great that it is costly, and that it requires much power and the volume efficiency is low during operation at a low speed.

An object of the present invention is to provide an improved variable discharge gear pump made by modifying a gear pump which is well-known for its simple construction, in particular a trocoid-toothed internal gear pump which requires less power and exhibits excellent volumetric efficiency during operation at a low speed.

A known internal gear pump is a fixed discharge pump in which the relative position between a gear set consisting of an inner rotor and an outer rotor and the suction and discharge ports is fixed. Its suction capacity and operating power increase with the increase in revolution speed. When it is necessary to decrease the supply of liquid to a hydraulic circuit, an excess liquid has to be returned to a tank by means of an unloading circuit including a relief valve or the like. Even if the supply of liquid is reduced, the power for the pump remains unchanged. Therefore, when the variable discharge rate is achieved without unloading the sucked liquid, the pump will be forced to work wastefully, thus wasting the driving energy from the power source.

In accordance with the present invention, there is provided a variable discharge gear pump comprising: a pump housing; an internal gear set mounted in the pump housing and having an outer rotor and an inner rotor having one less teeth than the teeth of the outer rotor and in engagement with each other with some amount of eccentricity; the pump housing being formed with a suction port and a discharge port sealed from each other; position changing means for changing the relative position between the gear set and the suction port and the discharge port; and actuating means for turning the position changing means within a predetermined range of angle.

With reference to the graph of Fig. 8 which shows variations in the suction and discharge volume, assuming that as shown in Fig. 9, the suction port 6 has its tail end 6a on line O-A passing the contact point between the inner rotor 4 and the outer rotor 5 where the volume of the pumping chamber reaches a maximum and has its front end 6b on line B-B' crossing the pumping chamber which has begun to open, the volume covered by hatching can be sucked by one pumping chamber. Supposing this amount to be vo, the pump can suck in volume Vo = vo × n (n indicates the number of teeth of the inner rotor for each rotation of the inner rotor.

When the eccentric ring or the disk is turned or the seal piece is circumferentially moved to shift the angular position of the suction port with respect to the gear set by an angle of θ, the suction volume for each pumping chamber will be equal to the difference between a and b in Fig. 10. Assuming this difference to be v, then $v = a - b = f(\theta, \theta') \leqq vO$. In this situation, the pump can suck $V = v \times n$ for each rotation of the inner rotor. θ' is a variable determined by the shape of teeth of the rotor, the angle of rotation θ and the distance H in Fig. 9. The volume V can be indicated by an equation $V = f$ (gear factors, H, α, and θ). The suction capacity V (equal to the discharge capacity) can be varied by controlling the angle θ.

The internal gear pump in accordance with the present invention is provided with an eccentric ring for changing the track of the outer rotor, a disk formed with the openings communicating with the suction and discharge ports or a sealing piece for displacing the tail end of the suction port. The eccentric ring, the disk or the sealing piece are turned or displaced to change the relative position between the gear set and the suction and discharge ports, thereby changing the suction capacity. Thus as shown in Fig. 11, when it is required to deliver a liquid Q1 in quantity, a fixed discharge pump has to use excess power to unload the liquid in excess of Q1, consuming much energy from the power source, whereas a variable discharge pump can adjust the suction capacity to the required volume Q1, thus saving energy.

Variable discharge vane pumps for general use has its disadvantage that the number of parts is so great that it is costly and complicated in mechanism. In contrast, since the pump according to the present invention is an internal gear pump, it is simple in construction, inexpensive and reliable, and will be advantageously used as a pump to be mounted on an automobile which has to be less fuel consumptive and reliable.

Other features and objects of the present invention will become apparent from the following description taken with reference to the accompanying drawings, in which:

Fig. 1 is a sectional view of the first embodiment in accordance with the present invention;

Fig. 2 is a front view of the same as seen with its cover plate removed;

Fig. 3 is a front view of the same showing the relative positions of a housing, an eccentric ring, and suction and discharge ports;

Figs. 4 and 5 are front views showing examples of driving mechanism for the eccentric ring;

Fig. 6 is a sectional view of the second embodiment;

Fig. 7 is a front view of the same showing the relative positions of the pump housing, the disk, and the suction and discharge ports;

Fig. 8 is a graph showing variations in the suction and discharge volumes for one pumping chamber when two rotors having nine and ten teeth are used;

Fig. 9 is a diagrammatic view showing how the pump of the present invention works;

Fig. 10 is a graph showing variations in the suction and discharge volumes with the same rotors as in Fig. 8 used but the position of the suction port displaced;

Fig. 11 is a graph comparing the flow rate and the power required for a fixed discharge pump with those for a variable discharge pump;

Fig. 12 is a sectional view of the third embodiment of according to this invention; and

Fig. 13 is a front view of the same showing the relative positions of the pump housing, the seal piece, and the suction and discharge ports.

Figs. 1 to 3 show the first embodiment of the pump according to the present invention in which the relative position between a gear set and suction and discharge ports are changed by means of an eccentric ring.

In the drawings, numeral 1 designates a pump housing which comprises a housing body 1a and a cover plate 1b and in which are mounted an eccentric ring 2, an outer rotor 3 and an inner rotor 4. Numeral 5 indicates a drive shaft for the inner rotor 4. The housing body 1a is formed with a suction port 6 and a disharge port 7 as shown in Figs. 1 and 3. The outer rotor 3 is in engagement with the inner rotor 4 having one less teeth than the former in an eccentric relation so that the centers of two rotors will be spaced from each other by a certain distance (e.g. by a distance "e" shown in Fig. 2). The eccentric ring 2 has its inner periphery concentric with the outer rotor 3 and the diameter at its inner periphery is substantially the same as the outer diameter of the outer rotor 3, whereas its outer periphery is concentric with the inner rotor 4 and has substantially the same diameter as the diameter at the inner periphery of the housing body 1a which is concentric with the outer rotor 3. The eccentric ring 2 is adapted to rotate around an axis concentric with the inner rotor 4.

The eccentric ring 2 may be provided on its end face with a boss concentric with the inner rotor 4, the boss being received in a recess formed in the housing body 1a to rotatably hold the eccentric ring concentrically with the inner rotor 4. With this arrangement, the outer periphery of the eccentric ring 2 and the inner periphery of the housing body 1a do not necessarily have to be concentric with the inner rotor 4. But the pump can be easily manufactured if the eccentric ring 2 is held rotatably and concentrically with respect to the inner rotor 4 as in this embodiment.

When the eccentric ring 2 of the pump in the first embodiment is turned clockwise or counterclockwise by an angle of θ, its inner periphery will be displaced from the position shown by full line in Fig. 3 to the position shown by chain line, thus shifting the track of the outer rotor 3 and moving the center of the pumping chambers at the maximum and minimum volumes from line C in Figs. 2 and 3 onto line C'. This will produce a condition as if the suction port 6 and the discharge port 7 are turned counterclockwise or clockwise by an angle of θ with respect to the gear set, resulting in that the suction volume decreases for the abovesaid reasons.

Figs. 4 and 5 show examples of mechanisms for turning the eccentric ring 2 within a predetermined angle range.

Fig. 4 shows a driving mechanism adopted for the pump shown in Fig. 1, which comprises an input lever 8 fixed to the eccentric ring 2 and having its one end protruding out of the housing through a circumferentially extending slit 9 formed in the cover plate 1b.

Another mechanism shown in Fig. 5 comprises a circumferentially extending slit 10 formed in the housing body 1a and a key way 11 formed in the eccentric ring 2 so as to communicate with the slit 10. A rack 12 having its projection engaged in the key way 11 moves linearly back and forth to turn the eccentric ring 2. Other types of driving mechanisms may be used such as one provided with coacting magnets which can rotate the ring 2 without the necessity of boring a hole in the housing.

Figs. 6 and 7 show the second embodiment of the pump in which a disk is provided. As shown in Fig. 6, the pump is provided with a disk 13 between the housing body 1a and the end face of the internal gear set comprising an outer rotor 3 and an inner rotor 4. The disk 13 is formed with openings 6' and 7' which communicate with the suction ports 6 and discharge port 7, respectively. Except that the disk 13 is arranged concentrically with the inner rotor or the outer rotor (in Figs. 6 and 7, concentrically with the inner rotor 4) in place of the eccentric ring, this embodiment is substantially the same as the first embodiment. In operation, the disc 13 is

turned by means of either of the above-described driving mechanisms (in the drawings, the one comprising the input lever 8 and the slit 10 is shown) to change the positions of the openings 6' and 7' with respect to the gear set held in a fixed position. The suction capacity varies on the same principle as described above.

Figs. 12 and 13 show the third embodiment in which sealing pieces are employed. The housing body 1a is formed at two places facing the end face of the gear set with sealing surfaces for the pumping chambers. One of the sealing surfaces is formed between the tail end 6a of the suction port and the front end 7a of the discharge port to provide the maximum volume for the pumping chamber. The other sealing surface is formed between the front end 6b of the suction port and the tail end 7b of the discharge port to provide the minimum volume for the pumping chamber. With the pump shown in Figs. 12 and 13, the sealing surface for the pumping chamber at the maximum volume is formed with an arcuate groove 14 having substantially the same depth as that of the suction port 6 and the discharge port 7 and having a uniform radial width so as to extend from the tail end 6a of the suction port 6 to the front end 7a of the discharge port 7. In the arcuate groove 14 is circumferentially movably mounted a seal piece 15 having its both sides and bottom side sliding on the surface of the groove 14 and having the other surface in contact with the end face of the gear set to seal the opening of the pumping chamber.

In this embodiment, as an example of the working mechanism, a circumferential slit 10 is formed in the housing body 1a and an input lever 8 is provided on the seal piece 15 so as to have its one end protruding through the slit 10.

The input lever 8 can be operated to slide the piece 15 circumferentially through an angle within the range of the space between the slit 10 and the lever 8 so as to displace the tail end 6a of the suction port 6. From the fact that the position of the gear set remains unchanged during this displacement, it follows that each pumping chamber is closed up before it reaches the maximum volume point, thus reducing the suction capacity.

If the sealing piece 15 is provided at the front end side of the suction port to displace the tail end of the discharge port, a given quantity of liquid which increases with the extent of the displacement will be left undischarged in each pumping chamber, reducing the discharge rate. Although one sealing piece 15 provided at either of the two sealing portions would be sufficient to obtain a satisfactory result, if two sealing pieces 15 are provided at both of the sealing portions, a pump with a wider volume variation than the first and second embodiments can be manufactured.

Claims

1. A variable discharge gear pump comprising: a pump housing;

an internal gear set mounted in said pump housing and having an outer rotor and an inner rotor having one less teeth than the teeth of said outer rotor and in engagement with each other with some amount of eccentricity;

said pump housing being formed with a suction port and a discharge port sealed from each other;

position changing means for changing the relative position between said gear set and said suction port and said discharge port; and

actuating means for turning said position changing means within a predetermined range of angle.

2. A variable discharge gear pump as claimed in claim 1, wherein said position changing means is an eccentric ring mounted between said pump housing and said outer rotor so as to be rotatable around an axis concentric with said inner rotor and having an inner diameter which is substantially the same as the outer diameter of said outer rotor.

3. A variable discharge gear pump as claimed in claim 2, wherein said eccentric ring has an outer diameter which is substantially the same as the inner diameter of said pump housing and has an outer periphery concentric with said inner rotor.

4. A variable discharge gear pump as claimed in claim 1, wherein said position changing means is a disk mounted between the end face of said gear set and said pump housing so as to be rotatable around an axis concentric with one of said rotors, and formed with two openings which communicate with said suction port and said discharge port, respectively.

5. A variable discharge gear pump as claimed in claim 1, wherein said position changing means is a sealing piece tightly but movably mounted in an arcuate groove, forming at least one of the sealing surfaces for a pumping chamber, said arcuate groove having a uniform width and a uniform depth and forming said suction port and said discharge port.

FIG.6

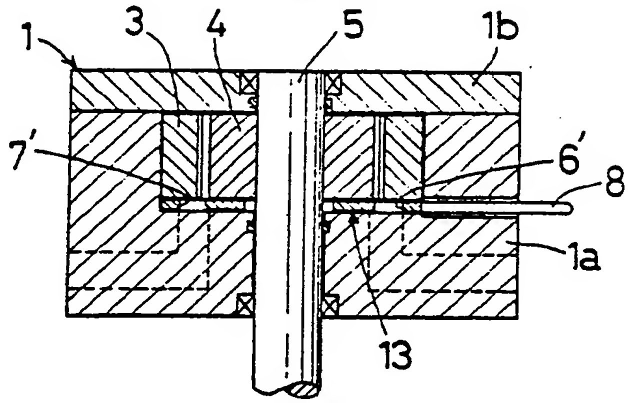

FIG.7

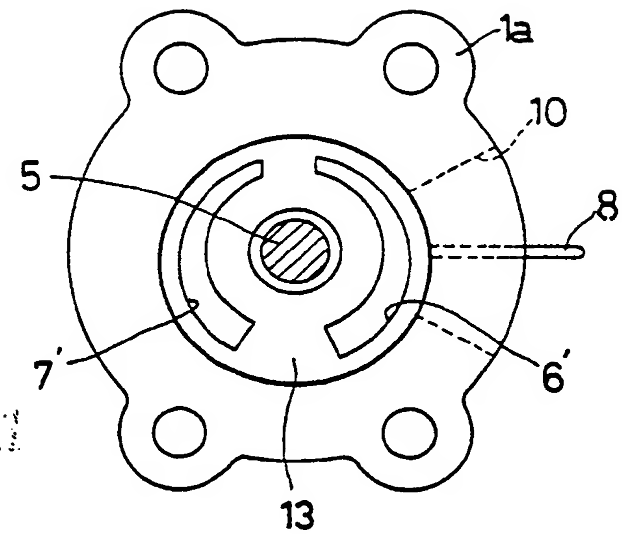

FIG. 8

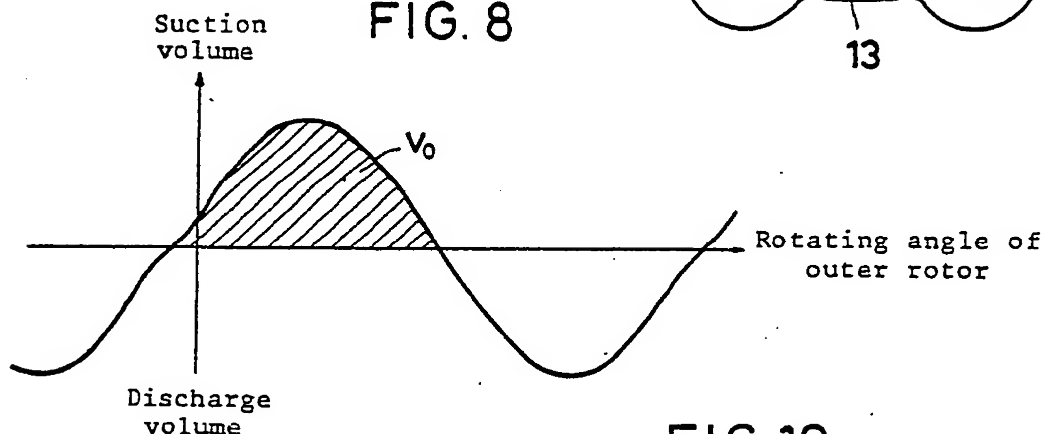

FIG.10

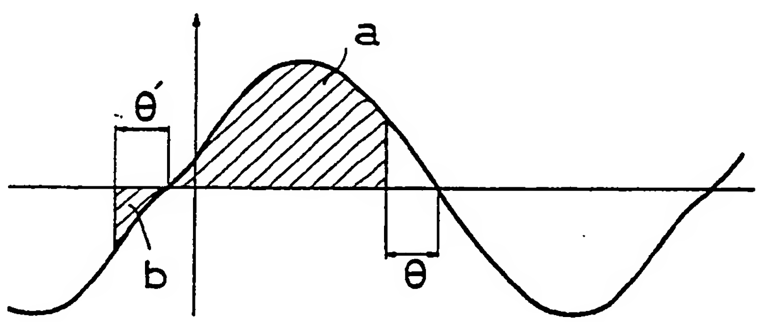

FIG.9

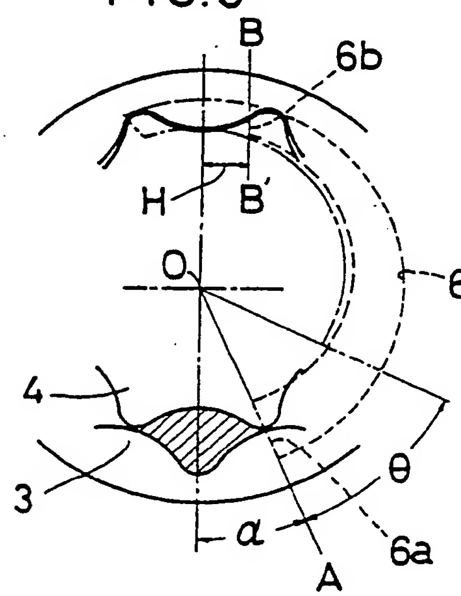

FIG. 1

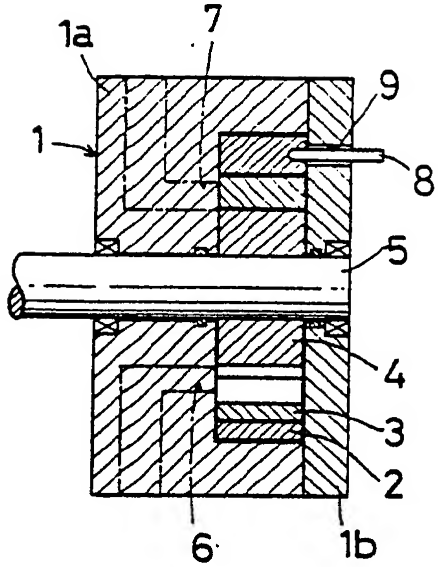

FIG. 2

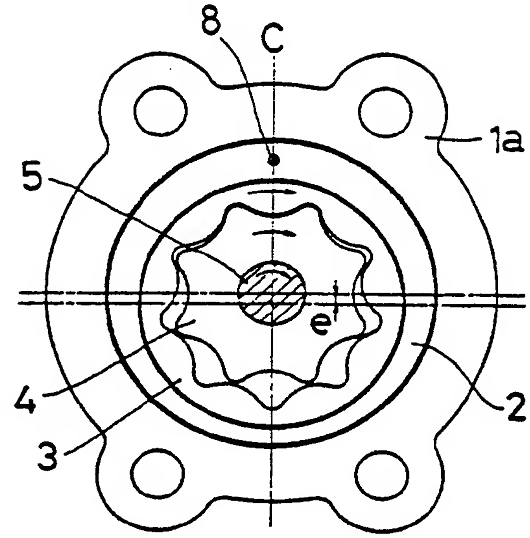

FIG. 3

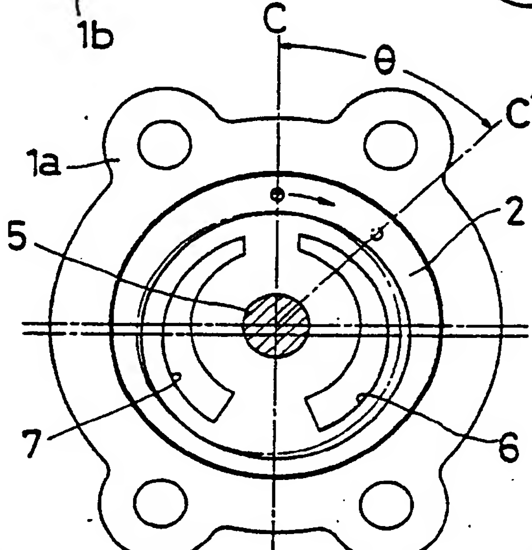

FIG. 4

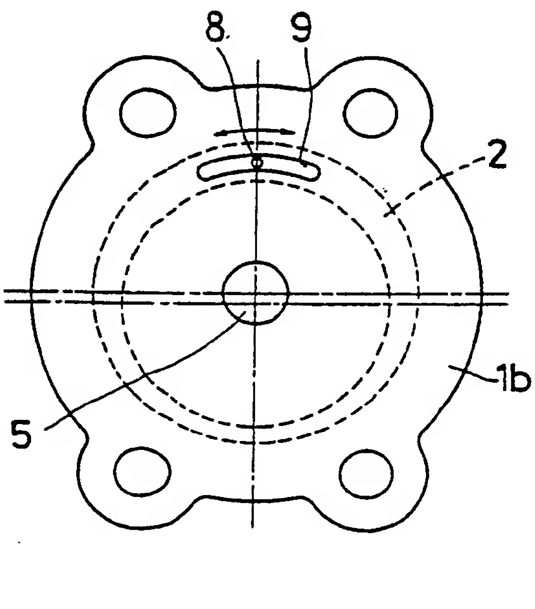

FIG. 5

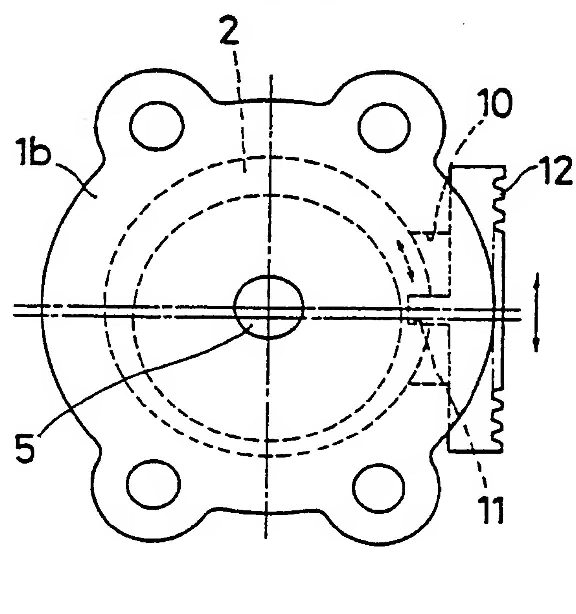

FIG. 11

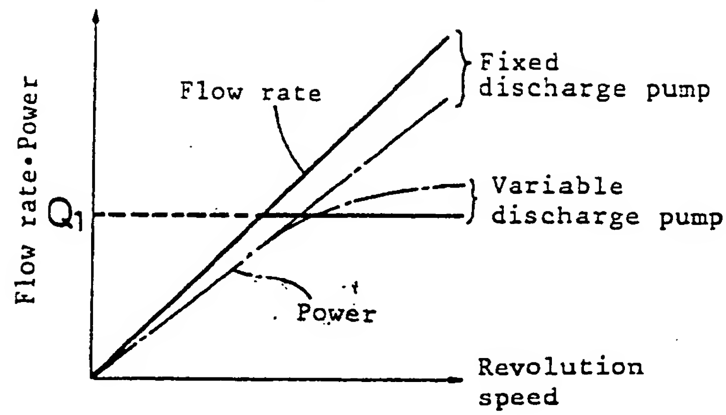

FIG. 12

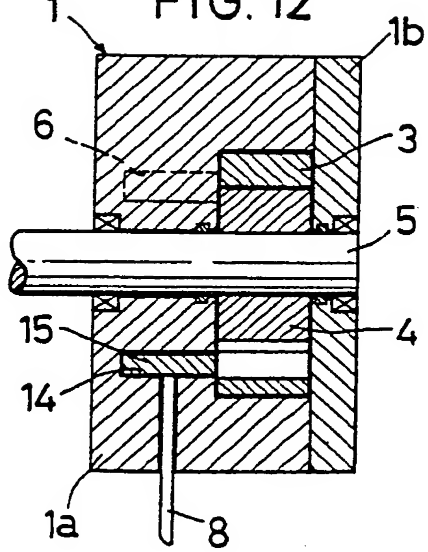

FIG. 13